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DELINEATION AND MAPPING OF SOIL AVAILABLE IRON AND COPPER STATUS IN SOILS OF SALEM DISTRICT OF TAMIL NADU USING GIS AND GPS TECHNIQUES

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ABSTRACT

The study was conducted in soils of Salem district of Tamil Nadu to understand the available micronutrient status in soil. Totally 1691soil samples were collected @ 4 samples per village covering 385 panchayat villages in 20 blocks of Salem district following the standard procedure of soil sample collection. GPS data (Latitude ºN and Longitude ºE) were recorded along with sample collection. Samples were analyzed for DTPA-Fe (Di-ethylene Tri-amine Penta Acetic acid extractable Iron) and DTPA-Cu (Di-ethylene Tri-amine Penta Acetic acid extractable Copper). Nutrient index values, fertility ratings and percentage deficiency were calculated from the analytical results. Thematic maps were prepared using Arc GIS software. Fertility rating for available Fe was high in Attur, Kolathur, Mecheri, Omalur, Ayodhiyapattinam, Panamarathupatti, Salem and Veerapandi blocks and it was adequate in Kadaiyampatty, Taramangalam, Idappadi and Konganapuram blocks. The remaining blocks showed very high fertility rating. The low fertility class for DTPA-Cu was noticed in Nangavalli, Mecheri and Konganapuram blocks while it was adequate in Macdonalds Choultry block. The high fertility rating was observed in Sangagiri, Omalur, Yercaud, Valapady and Gangavalli blocks. The remaining blocks fell under very high fertility rating Use of newly improved technologies like global positioning system (GPS) and geographic information systems (GIS), facilitate soil micronutrient mapping and provide quantitative support for the decision and policy making to improve agricultural approaches for the balanced nutrition of crops.

KEYWORDS: Di-Ethylene Tri-Amine Penta Acetic Acid (DTPA), Nutrient Index Values, Fertility Ratings, Thematic Maps, GIS and GPS

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INTRODUCTION

Micronutrient deficiencies are very common in soils of India. It should be corrected by the application of fertilizers and organic manures. The major reasons for the emerging deficiencies are use of high yielding varieties, increased use of high-analysis NPK fertilizers and decreased addition of organic manure to soil. The availability of metal ions (Fe, Cu) increases with increase in organic matter because organic matter may act as chelating agent. The organic carbon, EC and silt are the main soil characteristics play a major role in controlling the availability of Zn, Cu and Fe. Manganese, however is joined by two more factors *i.e.* clay and BSP which were found crucial in deciding its availability (Sharma and Chaudhary, 2007).

The analysis of soil samples collected from various states of India has indicated that, 49 per cent of soils are deficient in Zn, 12 per cent in Fe, 5 per cent in Mn, 3 per cent in Cu, 33 per cent in B and 11 per cent in molybdenum (Velu *et al.,* 2008). Geographic Information System (GIS) provides scientists, planners, managers and decision makers an efficient way of combining and analyzing georeferenced and descriptive data from different sources for better understanding and management of natural resources. The integration of spatial and attribute database within a GIS environment provides efficient data handling for rural planning and management (Fernandez *et al.,* 1993). White *et al.* (1997) used geostatistical analysis, interpolation (Kriging) and GIS for developing maps illustrating the geographic distribution of total Zn in surface soils collected from 2888 sampling sites at USA.

MATERIALS AND METHODS

Salem is one of district is bound on the North by Dharmapuri district, on the South by Namakkal and Erode districts, the Western Ghats in the West and Villupuram district in the East. The district is having North Latitude between 11^0 14` and $12^0$ 53` and East Longitude between 77^0 44` and $78^0$ 50`. The geographical area of the district is 5,20,134 ha. The district comprises of twenty blocks viz., Salem, Veerapandi, Panamarathupatti, Ayodhiyapattinam, Valapady, Yercaud, Kolathur, Nangavalli, Mecheri, Omalur, Taramangalam, Kadaiyampatti, Attur, Peddanaickenpalayam, Talaivasal, Gangavalli, Sangagiri, Macdonalds Choultry, Idappadi and Konganapuram with 385 Panchayat villages. The geo-referenced surface soil samples were collected from the Panchayat villages of Salem district to understand available micronutrient status. Four samples were collected from each Panchayat village randomly following the standard procedures of soil sample collection. Totally 1691 samples were collected. GPS reading were noted for each sampling site. The collected soil samples were processed properly. Fe and Cu were extracted with DTPA (0.005M Diethylene Triamine Penta Acetic Acid + 0.1M Triethanolamine + 0.01 M CaCl2) extractant adjusted to pH 7.3 ± 0.5 using 1:1 dilute HCl at 1:2 ratio (Soil : DTPA-extractant) and estimation was done using Atomic Absorption Spectrometer (Lindsay and Norvell, 1978). The soil samples were categorized into low (<3.7 mg kg^{-1}), medium (3.7 – 8.0 mg kg^{-1}) and high (>8 mg kg^{-1}) for Fe and low (<1.2 mg kg^{-1}), medium (1.2-1.8 mg kg^{-1}) and high (>1.8 mg kg^{-1}) for Cu.

Nutrient index values were calculated using the following formula

NIV = [(PH*3) + (PM*2) + (PL*1)] / 100

Where,

NIV = Nutrient Index Value

PL, PM and PH are the percentage of soil samples falling in the category of low, medium and high nutrient status and given weightage of one, two and three respectively (Ramamurthy and Bajaj, 1969). Fertility ratings and corresponding index values are given in table 1.

Table 1: Fertility Rating Class and Nutrient Index Value

Fertility Rating Class	Nutrient Index Value
very high	>2.67
High	2.33 to 2.67
adequate	2.00 to 2.33
marginal	1.67 to 2.00
Low	1.33 to 1.67
very low	<1.33

Using Raster to Vector software (R2V) district map of Salem (1:50,000) was vectorised, and then exported into Arc-GIS software. The database on the analysis of soil available micronutrients (Fe and Cu) was developed using Microsoft Excel., The database was exported into Arc-GIS software for preparing thematic maps.

RESULTS AND DISCUSSIONS

The available Fe content in the soils of Salem district ranged from 0.9 to 82.2 mg kg^{-1} with a mean of 14.3 mg kg^{-1} (Table 2). The highest DTPA-Fe was observed in the soils of Yercaud (82.2 mg kg^{-1}) followed by Konganapuram (77.2 mg kg^{-1}) and Peddanaickenpalayam (72.7 mg kg^{-1}) blocks while the lowest available Fe was registered in soils of Panamarathupatti (0.9 mg kg^{-1}) block (Table 2). Nearly about 3.1, 31.5 and 63.4 per cent samples were grouped under low, medium and high category respectively (Table 2). The problem related to iron deficiency is mainly due to its available pool rather than the total content in the soil (Brar *et al*., 2008). The most common cause of Fe deficiency is alkaline soil pH and when soil pH exceeds 7.0, the availability of Fe in the soil is greatly reduced. At high pH, Fe may be precipitated as insoluble Fe $(OH)_2$ (Sharma *et al*., 2003). Kadaiyampatty block showed higher per cent deficiency which may be attributed to the coarse texture of these soils and is in line with the observations of Katyal and Rattan (2003).

Table 2: Range, Mean Values, Percent Sample Category, NIV and Fertility Rating of DTPA – Fe for all the Blocks in Salem District

S. No.	Name of the Block	No. of Samples Collected	Range	Mean Value	Percent Sample Category			NIV	Fertility Rating
					Low	Medium	High		
1	Attur	80	2.0-26.9	9.0	7.5	41.3	51.2	2.44	High
2	Gangavalli	72	2.5-54.1	19.3	1.4	1.4	97.2	2.96	Very high
3	Peddanaickenpalayam	172	3.5-72.7	20.1	0.6	8.1	91.3	2.91	Very high
4	Talaivasal	144	5.8-70.9	20.1	0	13.9	86.1	2.86	Very high
5	Kolathur	60	2.6-32.9	10.2	3.3	50.0	46.7	2.43	High
6	Mecheri	72	4.5-41.8	10.1	0	48.6	51.4	2.51	High
7	Nangavalli	56	6.0-56.9	15.7	0	14.3	85.7	2.86	Very high
8	Kadaiyampatty	76	2.2-21.8	7.5	11.8	52.7	35.5	2.24	Adequate
9	Omalur	144	1.5-45.8	12.1	7.6	26.4	66	2.58	High
10	Taramangalam	72	3.5-26.6	8.3	1.4	65.3	33.3	2.32	Adequate
11	Ayodhiyapattinam	128	2.0-31.8	9.3	10.9	43.8	45.3	2.34	High
12	Panamarathupatti	88	0.9-23.6	8.8	5.7	47.7	46.6	2.41	High
13	Salem	55	4.4-27.0	10.4	0	34.5	65.5	2.66	High
14	Valapady	96	5.5-49.9	16.8	0	8.3	91.7	2.92	Very high
15	Veerapandi	103	2.6-36.6	10.7	4.8	34.0	61.2	2.56	High
16	Idappadi	52	4.0-26.4	8.3	0	71.1	28.9	2.29	Adequate
17	Konganapuram	40	3.1-77.2	11.4	5.0	67.5	27.5	2.23	Adequate
18	Macdonalds Choultry	56	2.3-22.9	10.6	1.8	14.3	83.9	2.84	Very high
19	Sangagiri	90	3.8-28.7	11.2	0	28.9	71.1	2.71	Very high
20	Yercaud	35	20.3-82.2	56.8	0	0	100	3.00	Very high
District		**1691**	**0.9-82.2**	**14.3**	**3.1**	**31.5**	**63.4**	**2.60**	**High**

The fertility rating for DTPA-Fe based on nutrient index values ranged from adequate to very high and as a whole the district showed high Fe status. There was no very low, low and marginal Fe fertility rating in Salem district.

Table 3: Range, Mean Values, Percent Sample Category, NIV and Fertility Rating of DTPA – Cu for all the Blocks in Salem District

S. No.	Name of the Block	No. of Samples Collected	Range	Mean Value	Percent Sample Category			NIV	Fertility Rating
					Low	Medium	High		
1	Attur	80	0.6-5.8	2.5	1.2	21.3	77.5	2.76	Very high
2	Gangavalli	72	0.3-4.8	2.3	11.1	26.4	62.5	2.51	High
3	Peddanaickenpalayam	172	0.5-6.0	2.8	4.1	13.9	82.0	2.78	Very high
4	Talaivasal	144	0.6-6.1	2.6	0.7	16.7	82.6	2.82	Very high
5	Kolathur	60	0.9-8.0	3.2	1.7	8.3	90.0	2.88	Very high
6	Mecheri	72	0.6-3.8	1.3	51.4	43.0	5.6	1.54	Low
7	Nangavalli	56	0.4-2.6	1.1	66.1	26.8	7.1	1.41	Low
8	Kadaiyampatty	76	1.0-9.8	2.9	1.3	19.7	79.0	2.78	Very high
9	Omalur	144	0.6-20.9	2.3	6.9	38.9	54.2	2.47	High
10	Taramangalam	72	1.4-8.5	2.9	0	9.7	60.3	2.90	Very high
11	Ayodhiyapattinam	128	0.2-10.0	2.7	3.1	20.3	76.6	2.73	Very high
12	Panamarathupatti	88	1.2-8.1	3.1	0	6.8	93.2	2.93	Very high
13	Salem	55	1.8-8.4	4.2	0	1.8	98.2	2.98	Very high
14	Valapady	96	0.6-4.0	1.9	11.5	37.5	51.0	2.39	High
15	Veerapandi	103	1.0-8.1	2.7	1.0	13.6	85.4	2.85	Very high
16	Idappadi	52	1.2-8.0	2.7	0	25.0	75.0	2.75	Very high
17	Konganapuram	40	0.6-2.6	1.1	70	15.0	15.0	1.45	Low
18	Macdonalds Choultry	56	0.7-5.7	1.7	26.8	41.1	32.1	2.05	Adequate
19	Sangagiri	90	0.9-3.9	2.0	7.8	26.7	65.5	2.58	High
20	Yercaud	35	1.1-8.8	3.2	5.7	25.7	68.6	2.63	High
District		**1691**	**0.2-20.9**	**2.5**	**13.5**	**21.9**	**64.6**	**2.51**	**High**

The DTPA-extractable Cu status of the soils of Salem district ranged from 0.2 to 20.9 mg kg^{-1} with a mean of 2.5 mg kg^{-1} (Table 3). The mean values showed that the highest available Cu was recorded in Salem (4.2 mg kg^{-1}) followed by Kolathur and Yercaud (3.2 mg kg^{-1}) blocks. The mean available Cu status was below the critical limit in the blocks of Nangavalli and Konganapuram (1.1 mg kg^{-1}) blocks while considering the critical limit of 1.20 mg kg^{-1} followed for Tamil Nadu soils. The natural concentration of Cu in soils depends primarily on the geochemistry of parent material (De Temmerman *et al*., 2003) and exhibited high spatial variability over heterogeneous lithologies. Concentration of Cu in soil can be influenced by soil properties, such as pH, organic matter content, cation exchange capacity, content of clay, fine silt, coarse silt, and available P (Pendias and Pendias, 2001; Sterckeman *et al*., 2004; Vega *et al.,* 2004; Mico *et al*., 2006). In this district, 13.5 per cent samples showed available Cu status of less than the critical limit of 1.2 mg kg^{-1}. Copper deficiencies were mainly reported in the soils with low organic matter content and high pH and might be the reason for deficiency in some soil samples. Decreased availability of copper at high pH might be due to precipitation of copper as its hydroxides. Newly formed hydroxides would have either become the part of lattice or occluded with the hydroxides of Fe, Al and Mn (Jegan and Subramanian, 2006).

Salem block recorded the highest percentage of samples under high category (93.2 %) which might be due to agricultural practices and application of organic manures or Cu containing inorganic fertilizers to soils (Prasad *et al*., 1984; Munoz *et al.,* 2007; Nicholson *et al*., 2003). The nutrient index values worked out for Cu availability in the soils of Salem district indicated “low to very high” rating (1.41 to 2.98). The mean nutrient index value showed “High” (2.51) Cu availability (Table 3). Fertility map was prepared for Fe (Figure 1) and Cu (Figure 2) based on nutrient index values using Arc GIS software.

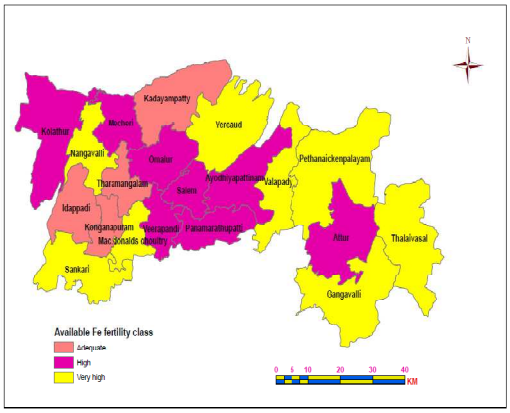

Figure 1: Fertility Map for Available Fe

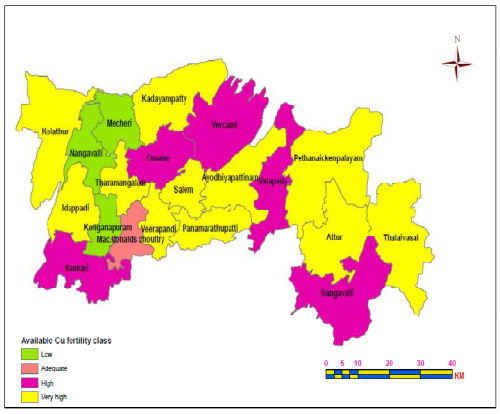

Figure 2: Fertility Map for Available Cu

CONCLUSIONS

From the study conducted in soils of Salem district it is found that the availability of Fe and Cu are sufficient in general and required to be applied in specific situations as per the need. The percentage of sample under low category for DTPA extractable micronutrients viz., Fe and Cu were 3.1 and 13.5 per cent respectively, whereas the medium category were 31.5 and 21.9 per cent respectively and under high category were 63.4 and 64.6 per cent respectively. The thematic maps prepared based on the nutrient index values can be used for the management of soil. Use of newly improved technologies like global positioning system (GPS) and geographic information systems (GIS), facilitate soil micronutrient mapping and provide quantitative support for the decision and policy making to improve agricultural approaches for the balanced nutrition of crops.

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